A Study of Pharmaceutical Compounds through Spectroscopic Technique

Synopsis

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Introduction:

In the race of development and progression of human kind, the intervention of material is most crucial. Hence the detailed understanding of materials is quite necessary. For the same reason the scientific world is more curious about probing into the different kinds of existing materials and the gathered information is being utilized to prepare more efficient materials.

One of the most important applications of materials is in the field of pharmacy. The pharmaceutical industries are always in the search of new potent substances which can be utilized to design drugs and medicines. The existence of intermolecular interactions among the molecules of same substance and their mixtures with others makes the substances suit for their applications. Hence one has to get the information regarding inter and intra-molecular behavior and molecular dynamics in their pure form and binary mixtures as well.

Various spectroscopic techniques reveal the required information about the chemicals and their mixtures. The dielectric spectroscopy is one among them [1-4].

In present proposal of research work, the dielectric spectroscopic technique is decided to be used for investigating intermolecular interactions and the dynamics in some pharmaceutical compounds along with their binary solutions with polar or non-polar solvents.

Literature Review:

The literature survey reveals that there is no limitation in the pharmaceutical applications. The dielectric study of various pharmaceutical compounds has already been done and utilized for drug designing purpose. Many researchers performed the dielectric spectroscopy of various pharmaceutical compounds in their solid state but the similar study about the liquid substances is scares. Some of the previously done findings about the dielectric properties of some pharmaceutical compounds are as follows:

The dielectric properties of binary mixtures of Acetophenone with n-Hexanol have been done by S.P. Patel and A.N. Prajapati [5] by using high precision LCR meter. H. Hagerstrom et. al. [6] performed low frequency dielectric spectroscopy measurements to obtain information

about the compatibility of a drug containing gel and mucous tissue. In this study the drug ions are used as probes for measuring the conductivity with which they pass the interface between the gel and the mucus layer. Dielectric properties and hydrogen bonding interaction behavior in binary mixtures of glycerol with amides and amines have been demonstrated by R.J. Sengwa et. al. [7]. The dielectric properties of various pharmaceutically relevant mixtures [8] have been studied by D.A. Engers et. al. The dielectric spectroscopy also assists to enquire the thermal aging of pharmaceutical compounds [9]. The dielectric spectroscopic and molecular dynamic study of aqueous solutions of paracetamol has been done by V.A. Rana & T.R. Pandit [10]. J.B. Karakthala et. al. studied molecular dynamics of diclofenac potassium at 300.15 K temperature [11].

S.C. Mehrotra has played a vital role in the development of TDR (Time Domain Refloctometry) technique in India and has performed the dielectric relaxation studies of many systems. The dielectric spectroscopy of dielectric materials can be performed by applying frequency domain and time domain techniques. In TDR technique, a train of fast rising pulses is applied to a sample through a co-axial line. This method at very high frequency range was first developed by H Fellner-Feldegg [12]. S. Mashimo et. al.[13] to find complex permittivity of aqueous solutions.

At present, the largely contributing scientists in this research field are D. Bertolini[14], Y.D. Feldman [15,16], U. Kaatze [17], S.C. Mehrotra [18], R.J. Sengwa [19], V.A. Rana [20], A.C. Kumbharkhane [21] etc.

Objectives of research hypothesis:

- To select an appropriate pharmaceutical compound and solvent for a particular disease.
- To measure the complex permittivity of chosen pharmaceutical compounds and their binary mixtures with different types of solvents very precisely using TDR technique.
- To evaluate the relaxation time, static dielectric permittivity, dielectric loss and high frequency dielectric permittivity by using suitable mathematical models.
- To measure the refractive indices of associated binary mixtures.
- To study the molecular interactions and hydrogen bonding in the associated compounds and their binary mixtures using various parameters like Kirkwood correlation factor, thermodynamic parameters, etc.

Methodology to be adopted:

To investigate the molecular interactions and thermodynamic properties, the TDR technique proved to be very useful. In this technique a fast-rising step voltage is propagated in a sample through an ideal coaxial line of 50Ω characteristic impedance. The pulse reflected from the sample is captured and compared (as a function of time) with the shape of the incident pulse using digital serial analyzer. By means of suitable mathematical transformations, the frequency response of the sample can be calculated. This technique is being used for the determination of complex permittivity of different kinds of molecules at various frequency ranges. This may be anticipated to produce better dielectric relaxation parameters because the permittivity spectra are obtained by a single measurement.

The TDR technique consist of three major elements:

1. Fast rising tunnel diode pulse generator
2. Wide band sampling oscilloscope
3. Data-acquisition system

Dielectric permittivity at an optical frequency can be derived from the square of refractive index of the liquid. The refractive index of the liquid sample can be measured using Abbe's refractometer.

Importance of study/ society applications:

The following scientists are doing research in this field at national and international level:

International Status:

1. N. Shinyashiki, University of Tokyo, Tokyo, Japan
2. S. Yagihara, University of Tokyo, Tokyo, Japan
3. S. Sudo, Dept. of Physics, Tokyo City Univ. Tamazutsumi, Setagaya, Tokyo, Japan
4. A. Cataldo, Universita di Lecce, via Monteroni, 73100 Lecce, Italy
5. U. Kaatze, DrittesPhysikalischesInstitut Georg-August-Universitat Gottingen, Germany.
6. Y.D. Feldman, Department of Applied Physics, Hebrew University of Jerusalem, Jerusalem, Israel.

National Status:

1. S.C. Mehrotra, Dr. BAMU, Aurangabad, Maharashtra
2. R.J. Sengwa, JNV University, Jodhpur, Rajasthan
3. A.C. Kumbharkhane, SRTM University, Nanded, Maharashtra
4. V.A. Rana, Gujarat Univirsity, Ahmedabad, Gujarat

Significance of the study:

The dielectric relaxation measurements of liquid solutions impact largely on the fundamental study of materials. The present study is devoted to dielectric relaxation measurement of pharmaceutical compounds using TDR technique from few Hz to some GHz.

From this study, one can understand the orientation and hydrogen bonding among associating molecules through solute-solvent interactions. The proposed study may help to improve the applicability of these compounds in pharmaceutical industries. It also helps in drug design.

Work plan/ formulation and structure of study:

- **First Year:** To prepare the theoretical background of research problem and detailed literature survey. Then choosing the pharmaceutical compounds and appropriate solvent for the dielectric measurements.
- **Second Year:** To study the dielectric dispersion of selected compound at different frequencies. To evaluate the dielectric properties such as static dielectric permittivity, relaxation time, dielectric permittivity at high frequency and structural information of these systems. To measure the refractive indices and densities of these liquids.
- **Third Year:** Dielectric information extracted from data analysis of these systems will be used further for interpretations of molecular behavior. These interpretations will be published by writing research papers or presenting the work in conference/seminars. Finally, write up thesis and complete the research work.

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